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International Cooperation for Winter Wheat Improvement in Central Asia: Results and Perspectives

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Abstract: Crop production in Central Asia has long history going back to 2000-3000 years BC. The farming in the past was mainly concentrated in irrigated areas along the two main river basins: AmuDarya and Syr-Darya. Wheat cultivation in Central Asia in the 20th century concentrated primarily in rainfed area. The breeding work conducted at several stations in the region was initially based on local landraces and resulted in adapted varieties. However, the breeding work was not consistent and interrupted. Since 1991 the wheat became an important crop due to food security concern and replaced cotton in some areas. The modern varieties developed in the region are well adapted and combine yield potential, grain quality and disease resistance. At the same time a number of foreign varieties from Mexico, Russia, Turkey, USA and other countries are cultivated in the region. The international cooperation with centers like CIMMYT and ICARDA resulted in the establishment of international network of researchers sharing the germplasm, knowledge and experience. New jointly developed varieties are being officially tested and some already reached the farmers. Support provided to wheat variety development and promotion in the region from international agencies and organizations like FAO, German Agency for Technical Cooperation, US Department of Agriculture, Washington State University, Winrock International, and others is fundamental for the wheat grain production in Central Asia.

Key Words: Breeding, CIMMYT, Central Asia, Food Security, ICARDA, Wheat

History of farming in Central Asia

The region comprises the countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan with the overall population of almost 60 mln people and arable land of 8 mln ha (without Northern Kazakhstan) (Program Facilitation Unit, 2003). The agriculture of Central Asia has an ancient and interesting history representing the dynamic changes in the farming systems, choice of crops and cultivation technologies as well as the utilization of water – the key element of crop production in the region. Central Asia is a home to numerous wild species of cereals. During the Neolithic Era the tribes populating the foothills of Kopet Dag mountains on the territory of modern Southern Turkmenistan started to domesticate *Hordeum spontaneum*, dominating wild cereal in the region (Masson, 1971). Around 7000 years BC the tribes from Northern Iran brought wheat to the region and started its cultivation under rainfed conditions on a narrow strip of land between the mountains and the Karakum desert. Geouksuk oasis on the territory of modern Tedjen city developed first irrigation systems in the second part of the 4000 millenium BC. These tribes migrated Eats and South-East towards rivers Murgab and Zerafshan establishing new centers of crop cultivation, primarily wheat and barley. By the end of 2000 BC the irrigated farming was also established in the fertile valleys like Fergana, Gissar and along the rivers of Amudarya, Kashkadaria, Surhandaria and Vakhsh (Andrianov, 1969). Some irrigation canals built at that time in Fergana Valley are still used now.

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The other powerful invasion to the region was during the Bronze Age by the nomadic tribes from the North-East. These tribes were mainly involved in raising cattle. However, while migrating with the animals from the steppes in winter to the summer pastures in the mountains they planted wheat under rainfed conditions at mountain foothills and collected the grain while migrating back in early fall. These tribes occupied Northern part of Central Asia up to irrigated areas of Fergana and Gissar valleys and main rivers. Cereals dominated in the region providing essential part of diet for the tribes (Udachin and Shakhmetov, 1984). Thus, the irrigated and rainfed farming establish in Central Asia as early as 2000-3000 years BC expanded and diversified in the modern era. It witnessed the raise and fall of kingdoms, occupation of the region by neighboring tribes and establishment of the modern nations but essentially remained the same till the late 19th – early 20th century when modern agriculture started to develop. The region grows a number of crops and all of them are important. However, the current paper is devoted to wheat with the objective to demonstrate the changes in crop productivity achieved through breeding as well the results and perspectives of international cooperation in this area.

Wheat improvement in Central Asia

The archeological excavations on the territory of Central Asia showed that though *Triticum compactum* and *T. durum* were cultivated during the ancient times, *T. aestivum* or bread wheat became dominating crop 500 BC – 500 AC (Yakubtsiner, 1956). Local varieties well adapted to the region dominated until late XIX century when the region fell under Russia. The Russian government considered Central Asia as cotton producing region and with the development of the railroads it was easier to bring grain from Siberia or European Russia instead of producing in the region. At the beginning of the XX century with the yield of irrigated wheat and cotton being 1 t/ha the profitability of cotton was three times higher. However, by 1913 wheat was still a major crop occupying 49% of the land compared to 15% under cotton. The breakdown of wheat area (spring and fall planted, irrigated and rainfed) and yield in different regions of Central Asia in 1915 is given in Table 1. Interestingly, across Turkestan (name of Central Asia in the past) the share of rainfed spring wheat in total wheat area was 33% followed by irrigated winter wheat or fall planted wheat – 30%, irrigated spring wheat – 27% and rainfed fall planted wheat – 10%. The highest yield was demonstrated by fall planted irrigated wheat – 0.89 t/ha. The yield of irrigated spring wheat was equal to rainfed fall planted wheat – 0.73 t/ha. The productivity of rainfed spring wheat was the lowest – 0.56 t/ha (Udachin and Shakhmetov, 1984). With the time the share of spring planted wheat reduced significantly and presently fall planted wheat is a major crop in the region. By 1930 wheat occupied approximately 1.5 mln ha including 75 % under irrigation. With more priority given to cotton the area decreased by 1950s to less than 1 mln ha and only 30% of wheat was cultivated under irrigation (Udachin and Shakhmetov, 1984). Wheat regained its popularity in the 1990s when newly independent states of Central Asia put forward the objective of self-sufficiency in grain. The current area of wheat reaches 3 mln ha (Table 2).

The first systematic attempt to study the variability of wheat grown in the region was undertaken in 1909 by Turkestan Experimental Station near Tashkent which evaluated 300 entries collected in the region (Dorofeev, 1987). Most popular local land-races were Sary Magiz, Ala Biruk, Kzyl Bugday, Nar Kzyl, Ak Bugday. They represented native populations well adapted to the region with good drought and heat tolerance, tall, with fragile spikes. The second group of varieties was represented by introductions from Russia and Ukraine brought by peasants and kossaks who migrated to the region from European part and from Siberia. The varieties like Beloturka, Kubanka, Arnautka, Belokoloska and others adapted to the region and provided more responsive type of germplasm compared to local populations. Numerous wheat collections were conducted across the region including the one by famous N. Vavilov in 1916 who traveled from Tashkent to Pamir Mountains. The collections and expeditions covered the region very well.

By 1930-35 the network of wheat research stations was established across the region. Continuous wheat improvement work was conducted in Kazakhstan, Kyrgyzstan and Uzbekistan. Modern wheat breeding was established in 1970s and was well integrated with wheat breeding programs in Russia and Ukraine. The tendency for intensification of wheat production especially in irrigated and high rainfall areas resulted in the old varieties being subjected to higher fertilizer rates and lodging became a major constraint. The variety which successfully adapted to the higher inputs was Bezostaya 1

Table 1. Wheat area and yield in different regions of Central Asia in 1915 (Udachin and Shakhmetov, 1984).

Region	Area, (x 1000 ha)				Yield (t ha^{-1})			
	Irrigated		Rainfed		Irrigated		Rainfed	
	winter	spring	winter	spring	winter	spring	winter	spring
Syrdarya	106	215	52	118	0.75	0.73	0.67	0.65
Fergana	108	64	22	136	0.96	0.85	0.80	0.65
Samarkand	150	63	37	181	0.96	0.67	0.64	0.40
Ashgabad	29	20	3	3	0.66	0.32	0.51	0.16
Total	393	362	1114	438	0.89	0.73	0.72	0.56

Table 2. Wheat area, yield and production in Central Asia in 2001 (Source: Program Facilitation Unit, 2003).

Country	Area, x 1000 ha	Yield, t ha^{-1}	Production. Mln t
Kazakhstan*	10,826	1.2	12,910
Kyrgyzstan	478	2.5	1,190
Tajikistan	343	1.2	406
Turkmenistan	750	1.6	1,200
Uzbekistan	1,219	3.0	3,689

* including Northern Kazakhstan

from Krasnodar Agricultural Research Institute in Russia. Bred by Academician P.P. Lukjanenko this variety was and still a masterpiece of breeding covered millions of hectares in the USSR, Eastern Europe and Central Asia. Not only it contributed to production but also was an extremely successful parent in the development of new varieties. In regard to Central Asia this variety is still grown and preferred by some farmers who maintain low input production. The local varieties developed in the region in 1970-80s were characterized by good adaptation, high yield potential and normally good bread-making quality.

Wheat in Central Asia in the 1990s

With the break up of the USSR and the independence gained the wheat production in the region was highly prioritized and the area increased at the expense of cotton. The expansion of wheat in the 1990s required new varieties suitable for irrigation and higher inputs. With the exception of Kazakhstan and partly Kyrgyzstan, the existing local varieties were not suitable for production due to low yield potential, susceptibility to diseases and lodging. Initially in the mid 1990s varieties from Russia and particularly from Krasnodar Agricultural Research Institute played very important role. They covered almost entire irrigated wheat area in Uzbekistan and substantial part of land in Turkmenistan, some in Kyrgyzstan and Tajikistan (GTZ-CIMMYT, 2003). Varieties like Soratnitsa, Spartanka, Skiphyanka, Yuna provided high yield but were late and required up to 4-6 irrigations using the scarce water resources of Central Asia. They also turned out to be highly susceptible to yellow rust which devastated them during the epidemic of 1999 and 2000. These varieties were replaced in the beginning of 2000 by newer varieties more resistant to diseases: Kupava, Knyazhana, Kroshka, Polovchanka and others. Interestingly, all these varieties maintain the type of Bezostaya 1 though shorter and more responsive to inputs.

Table 3. Winter wheat varieties originated from international nurseries being officially tested in the countries of Central Asia.

Country	Year	Variety	Pedigree	Cross ID	Origin	Submitted by
Kazakhstan	2001	Egemen	BHR/AGA//SNI/3/TRK13	XWN84305	ORMXTCI	Kazakh ARI
	2002	Akdan	JUP/4/CLLF/3/II14.53/ODIN//CI13431/WA00477	SWM5069	MX	Red Fall St.
Kyrghyzstan	2001	Djamin	NS55-58/VEE	SWM833795	MXORTCI	Kyrgyz ARI
	2002		F.474S10.1		ROM	Kyrgyz ARI
	2002	Keremet	Hatusha/KAUZ//TRK13	CIT89100T	TCI	MIS Farm
	2002	Zagadka	CHAM6//F134.71/NAC	CIT922354	TCI	MIS Farm
	2002	Zubkov	1D13/MLT//KAUZ	SWM89Y029H	MXORTCI	MIS Farm
	2002	Azibrosh	OK82282//BOW/NKT	CMSW90M128	MX-CIT	MIS Farm
	2002	Aychurek	YMH/JAR//KKZ/4/63.122.66.2/NO66//LOV2/3/KVZ/HYS/5/EYS/BEZ	YE4615	YE-CIT	MIS Farm
	2002	Cholpon	PYN/BAU	SWM15182	MX	MIS Fram
Tajikistan	2000	Tacicar	TAST/SPRW//ZAR	ICWH840048	TCI	Tajik ARI
	2000	Norman	OR F1.158/FDL//BLO/3/SHI4414/CROW	ICWH860291	TCI	Tajik ARI
	1999	Kauz	JUP/BJY//URES	CM67458	MX	Tajik ARI
	2002	Alex	PYN/BAU	SWM15182	MXORTCI	Tajik ARI
	2002	Ormon	NWT/3/TAST/SPRW//TAW12399.75	ICWH900335	TCI	Tajik ARI
Turkmenistan	2000	Garagum	TRAKIA/KNR	TE3093	TE	Turkmen ARI
	2000	Guncha	HYS/7C//KRC(ES84-16)/3/SERI	SWM17323	MXTCI	Turkmen ARI
	2000	Bitarap	SN64//SKE/2*ANE/3/SX/4/BEZ/5/SERI	SWM866442	MXTCI	Turkmen ARI
Uzbekistan	2000	Dostlik	YMH/TOB//MCD/3/LIRA	SWM12289	MX	Gallyaoral ARI
	2002	Greacum 2002	8023.16.1.1/KAUZ	CMSW92WM00378S	MXTCI	Gallyaoral ARI
	2002	Ravat	OK82282//BOW/NKT	CMSW90M128	MXTCI	Gallyaoral ARI

Table 4. The yield performance of winter wheat varieties of different origin at three locations in Tajikistan in 2001.

Variety	Origin	Sovetsk.	Kurgan	Nau	Average	Rank
Steklovidnaya 24	Kazakhstan	3.63	3.45	3.00	3.36	1
PYN/BAU	Mexico-Tajikistan	3.66	3.25	3.02	3.31	2
Karlygash	Kazakhstan	3.54	3.55	2.60	3.23	3
Kauz	Mexico	3.64	3.07	2.92	3.21	4
Krasnovodopadskaya 25	Kazakhstan	3.49	3.30	2.70	3.16	5
Jagger	USA	3.40	3.20	2.85	3.15	6
Yanbash	Uzbekistan	3.51	3.10	2.77	3.13	7
Bezostaya 1 (LC)	Russia	3.38	3.05	2.80	3.08	8
Bogarnaya 56	Kazakhstan	3.34	3.37	2.25	2.99	9
Zhetisu	Kazakhstan	2.96	3.10	2.87	2.98	10
ZANDER-12	Mexico-Tajikistan	2.98	2.92	3.00	2.97	11
Krasnovodopadskaya 210	Kazakhstan	3.18	3.37	2.32	2.96	12
Ulugbek 600	Uzbekistan	3.06	3.50	2.30	2.95	13
7C (LC)	Mexico	2.24	3.50	3.10	2.95	14

The new winter wheat varieties developed in the 1990s by the national breeding programs were well adapted to the local environments and importantly were earlier and required less water for irrigation (GTZ-CIMMYT, 2003). Variety Almaly from Kazakhstan (6862-50431, Bulgaria x Bezostaya 1) which is resistant to yellow rust with good bread-making quality. Released in 2002, it is highly demanded by farmers and has potential to become a major variety in South-East of Kazakhstan replacing variety Steklovidnaya 24. Variety Naz also released by Kazakh Research Institute of Farming for rainfed conditions of Kazakhstan and Kyrgyzstan combine good tolerance to drought and resistance to yellow rust. Recent varieties from Kyrgyz Research Institute of Farming (Bermet, Dostyk, Kyzyl Dan, Kyal, Tilek) released for irrigated conditions and though possess very high yield potential have variable disease resistance and grain quality. Uzbek varieties Gairat, Chillaki, Ulugbek 600, Yanbash combine earliness and good yield potential providing competition to Russian varieties. Varieties Navruz and Sharora from Tajikistan though very high yielding lack resistance to yellow rust and have poor bread-making quality. In general the germplasm originating from the region and from Russia dominates the production though some European and American varieties have been entering the list or recommended varieties as well.

International cooperation in wheat improvement

Before 1991 when the countries of the region became independent cooperation on wheat improvement was taking place primarily in the framework of the USSR network of winter wheat breeding with little direct contacts with outside world. The germplasm from CIMMYT and ICARDA reached the region through the Vavilov Institute in Leningrad. The Green Revolution varieties such as Siete Cerros 66 were tested in the region and were released in the 1970s for irrigated conditions. Some farmers in Tajikistan still maintain and cultivate Mexican wheat. The exchange of germplasm and scientists was very limited.

Since 1994-95 the wheat research in the region was substantially influenced by the development of international linkages especially in breeding. The international centers CIMMYT and ICARDA established the germplasm exchange primarily through the winter wheat program Turkey-CIMMYT-ICARDA located in Turkey. Regular international nurseries from international programs in Turkey, Syria and Mexico were sent to the region for selection and utilization either directly as varieties or for crosses. At the same time the wheat varieties from the region were sent to Turkey and were globally tested through different nurseries. It appeared that the germplasm from international programs was very well adapted to the conditions of the region and assured healthy competition with the Russian and locally developed varieties. By 2003 several wheat varieties were officially tested in the region for possible release (Table 3). The advantage of these new varieties is high yield, excellent resistance to leaf diseases and especially yellow rust. The grain quality of this germplasm has to be verified during the tests. The sample yield data from Tajikistan is shown in Table 4 illustrating the diversity of the germplasm tested in the country and the relative performance of the introduced and local varieties.

Several international projects related to development of new varieties and their promotion are under way supported by German Technical Cooperation Agency (GTZ), USDA through Washington State University and other donors. The GTZ-CIMMYT project "Regional network on wheat variety promotion and seed production" established a network of research institutions and seed farms in the region with aggressive on-farm promotion of better technologies, varieties and seed. The network plays very important role in the regional germplasm exchange, movement of varieties, communication of scientists and publications. It also made significant efforts in broadening the international contacts. The project played key role in Tajikistan in the replacement of the old susceptible wheat varieties with better varieties from Kazakhstan, Turkey and USA. Jointly with Winrock International the project tests and promotes bed-planting cultivation of wheat which uses much less seed and water. The project International Cooperation for Agricultural Research (ICAR) supported by USDA through Washington State University and implemented jointly with CIMMYT provides small grants for on-farm promotion of new technologies and their components as well as research grants for investigations on priority areas for Central Asia and USA. CIMMYT and ICARDA from the very beginning prioritized training as an important component of the cooperation framework. Till now more than 70 individuals were trained outside of the region, primarily at center's headquarters in Mexico and Syria.

The main results of the international cooperation are the following:

- Enriched diversity of the wheat varieties cultivated in the region and farmer's access to new varieties combining yield potential and disease resistance;
- New contacts with international scientific community and establishment of joint research projects;
- Adoption of new wheat production technologies which save water and inputs;
- Regional network of researchers sharing the germplasm, knowledge and experience;
- Access of international research community to the genetic resources, germplasm and knowledge on wheat in Central Asia and their utilization for the benefit of humanity;
- Qualified trained scientists with language capacity and international experience.

The results of ten years of cooperation are very convincing and encouraging. The steps to be taken in the future very much depend on the direction which irrigated farming will take in the next 5-10 years. The history of wheat breeding in Central Asia demonstrates that during the last 100 years it transformed from a major crop in the region being grown both under irrigated and rainfed conditions to a crop almost entirely grown in the hills and mountains where irrigation is not possible. While cotton dominated, wheat research and breeding remained almost forgotten and in some countries was not continuous. As a result when the region needed the grain and turned to self-sufficiency in early and mid-1990s there were no varieties suitable for intensive production. This task is being successfully implemented. Uzbekistan reached self-sufficiency in 2002 and 2003. Tajikistan and Turkmenistan have increased the production substantially. The higher profitability of cotton per unit area remains a very strong factor to decrease the land under wheat. On the other hand the small private farmers see wheat as a guarantee for their essential food supply. The priorities for the future is development of wheat varieties and technologies which would provide higher yield using less land and water – a challenge not only for the scientists of Central Asia but for the global scientific community interested in the sustainable environmentally sound development of this region.

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